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The influence of the TaRL approach on the critical thinking ability of elementary school students in mathematics subject

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ABSTRACT

The results of the PISA study revealed that students have low critical thinking skills in Indonesia, especially in mathematics. This study aims to evaluate the effect of the Teaching at the Right Level (TaRL) strategy on the critical thinking skills of fourth-grade elementary school students in solving arithmetic problems in Yogyakarta. This study used a quantitative approach with a nonequivalent control group experimental design. The instruments used included essay tests, observation sheets, and documentation. Data were analyzed through descriptive statistics and t-tests to test the hypothesis. The results of the analysis showed that the TaRL strategy significantly improved students' critical thinking skills in four main aspects. The t-test produced a significance value of 0.000 (<0.05), indicating a significant difference between the experimental and control groups. The average posttest score of the experimental group reached 81.5, which is higher than that of the control group, which obtained an average of 76. This increase is illustrated in students' abilities to identify problems, analyze information, evaluate solutions, and logically convey arguments. These findings indicate that the TaRL strategy is effective in improving learning outcomes and contributes to strengthening students' critical thinking skills from an early age. Thus, the implementation of TaRL can be an alternative adaptive and transformative learning strategy to improve the quality of basic education in Indonesia.

1. Introduction

In recent years, the Indonesian Ministry of Education, Culture, Research, and Technology has initiated educational transformation through the implementation of the Independent Curriculum, which aims to improve the quality of learning by giving educational units the flexibility to design learning that suits students' needs [1]. The concept of "Independent Learning" carried in this curriculum is different from the 2013 Curriculum because it gives greater autonomy to teachers and students in the learning process, especially in designing materials according to students' ability levels [2], [3]. In the context of mathematics learning, this flexibility allows teachers to adjust the material based on initial diagnostic results. For example, if fourth-grade students have difficulty understanding the concept of division, teachers can first reinforce basic concepts such as addition and subtraction before moving on to more complex material. This shows the importance of a mastery-based learning approach, not just memorization. Research by Wawan *et al.* showed that students' low mastery of mathematics material is influenced by two main factors, namely teacher pedagogical skills and student learning motivation [4]. Based on observations and interviews conducted in August 2023 at one of the Muhammadiyah Elementary School Ngijon 1, it was found that the learning methods used still tend to be traditional, such as one-way lectures, and have not adopted a differentiated learning approach,

such as Learning with the Right Level. This has an impact on the lack of active student participation and low understanding of mathematical concepts. Therefore, this study aims to examine how the implementation of the Learning with the Right Level approach can improve the understanding of mathematical concepts in grade IV Muhammadiyah Elementary School Ngijon 1. This study also aims to identify factors that influence the effectiveness of implementing this approach in the context of Independent Curriculum learning.

The low interest in learning mathematics among elementary school students is an important concern in the world of education. According to Lazarides *et al*., most elementary school students do not show high enthusiasm for learning mathematics, one of which is caused by the dominance of lecture methods with minimal interaction and contextual approaches [5]. In fact, mathematics should be a means to develop students' critical thinking skills in dealing with real-life problems [6]. Critical thinking skills in mathematics include analyzing information, making inferences, and evaluating solutions logically [7]. However, in practice, the critical thinking skills of elementary school students have not yet developed optimally, as reflected in the low results of the national numeracy assessment [8]. One approach proposed to overcome this problem is to implement student-centered learning, as emphasized by the philosophy of Ki Hadjar Dewantara [9]. This approach emphasizes active [10], reflective [11], and contextual learning activities [12], which are believed to be able to improve students' literacy and numeracy more meaningfully [13]. Although various studies have discussed the importance of critical thinking in mathematics learning [6], [14]–[17], there is still limited research that specifically examines how the implementation of student-centered learning impacts the improvement of critical thinking skills in mathematics at the elementary school level. Therefore, this study aims to fill this gap by examining the effectiveness of problem-solving-based learning approaches in improving critical thinking skills in mathematics in elementary school students.

Teaching at the Right Level (TaRL) is a learning approach that focuses on mapping students' actual abilities and compiling teaching materials according to their level of mastery, not based on class or age [18]. This approach has been proven effective in improving basic literacy and numeracy skills in various developing countries, including India and several African countries [19]. On the other hand, critical thinking skills, which include the ability to analyze, evaluate, and draw conclusions, are essential competencies in mathematics learning [20]. However, the results of national and international studies show that the critical thinking skills of Indonesian students, especially at the elementary school level, are still at a low level [21]. Although several studies have shown the effectiveness of TaRL in improving learning outcomes in general, there are still limited empirical studies that specifically examine the effect of TaRL on the development of student's critical thinking skills, especially in the context of arithmetic learning in elementary schools. Therefore, this study aims to examine the effect of implementing the TaRL strategy on improving the critical thinking skills of grade IV Muhammadiyah Elementary School Ngijon 1. The main contribution of this study is to provide new empirical evidence regarding the effectiveness of the TaRL approach not only in terms of content mastery but also in strengthening high-level thinking skills, which are important demands in the Independent Curriculum.

2. Method

This study used a quantitative approach with a quasi-experimental design, specifically the Nonequivalent Control Group Design [22]. The research sample consisted of 40 fourth-grade students at Muhammadiyah Elementary School Ngijon 1, who were divided into two groups: class IV A (20 students) as the experimental group that received treatment using the Teaching at the Right Level (TaRL) approach and class IV B (20 students) as the control group that received conventional learning. The sampling technique was carried out purposively based on the equality of the initial characteristics of the class. The independent variable in this study is the application of the TaRL approach, while the dependent variable is students' critical thinking skills in mathematics. Critical thinking skills were measured using a descriptive test (essay) developed based on critical thinking indicators from Facione [23], including analysis, interpretation, evaluation, and inference. The test instrument has gone through a content validation process by three mathematics education experts and has a reliability test using a Cronbach's alpha coefficient of 0.55. Although classified as moderate, the instrument is still used considering the limitations of the field context and followed up with data triangulation through observation and documentation of student assignments. Data were collected through pretests and posttests and observations of learning activities using observation sheets compiled based on TaRL implementation indicators. Documentation sheets are used to record student assignments during the

learning process. Data analysis techniques include descriptive analysis (mean, median, mode, minimum, maximum, variance, and standard deviation) to describe the data profile. Before hypothesis testing is carried out, prerequisite tests in the form of normality tests (using Kolmogorov-Smirnov) and homogeneity tests (using Levene's Test) are carried out. The inferential analysis uses an independent sample t-test to test the difference in posttest scores between the experimental and control groups at a significance level of 0.05. The main instruments in this study consist of three types, namely:

- Critical Thinking Ability Test (Pretest and Posttest): This test is in the form of essay questions that are arranged based on critical thinking indicators according to Facione (2011), namely: (1) Analysis (ability to analyze problems); (2) Interpretation (ability to understand and explain the meaning of information); (3) Evaluation (ability to assess the truth or logic of an argument); (4) Inference (ability to draw conclusions from available information). The test consists of 5 contextual arithmetic questions that measure the four indicators, adjusted to the basic competencies of the grade IV elementary school curriculum, namely (1) Content validation was carried out by three expert lecturers in the field of mathematics education and instrument development; (2) The reliability of the instrument was tested through a limited trial on students in equivalent classes (outside the research sample), and a Cronbach's alpha coefficient of 0.55 was obtained. Although below the ideal threshold (0.70), the test was still used with consideration of data triangulation and adjustment of the field context.
- Learning Activity Observation Sheet: This sheet is used to record the implementation of the Teaching at the Right Level (TaRL) strategy during learning. The observation sheet is compiled based on the main steps of TaRL implementation, namely: (1) Initial diagnostics of student abilities; (2) Grouping based on ability level; (3) Giving assignments and materials according to the level of mastery; (4) Assessment of individual progress. External observers carry out observations to maintain objectivity.
- Student Assignment Documentation Sheet: Documents in the form of student work results are collected as additional data to assess the development of critical thinking skills during treatment. This data is also useful to support quantitative results through a form of triangulation.

The experimental implementation procedure was carried out in three main stages:

- Preparation Stage: (1) Preparing TaRL-based learning devices for experimental classes; (2) Conducting short training for class teachers regarding the implementation of the TaRL approach; (3) Conducting trials and validation of critical thinking test instruments.
- Implementation Stage: A pretest was given to both groups (experimental and control) to determine initial critical thinking skills. The treatment was carried out during 4 weeks of mathematics learning: (1) The experimental class uses the TaRL approach, where students are grouped based on initial diagnostic results and given material and exercises according to their level of mastery; (2) The control class uses conventional methods according to the learning implementation plan (RPP) applicable at the school.
- Evaluation Stage: (1) After treatment, a posttest was given to both groups; (2) Pretest and posttest data were analyzed to measure the increase in critical thinking skills and differences between the two groups; (3) Observation and documentation data were analyzed as supporting data to understand the TaRL implementation process.

3. Results and Discussion

In this study, the effect of applying the TaRL approach is the independent variable. The dependent variable is one's ability to use critical thinking when solving math problems. The measure of critical thinking was found in the least common multiple and greatest common factor problems. Students were given pretest questions at the beginning of the experimental and control classes to measure their initial ability. The TaRL approach was used to treat students in the experimental class, while the traditional learning model was used in the control class. Students were given post-test questions at the end of their education to determine their final proficiency level. Before conducting the hypothesis test, the answer checked for normality. If the result shows $\alpha > 0.05$, the data is normally distributed; if the result shows $\alpha > 0.05$ for the homogeneity test, the data is homogeneous.

3.1. Observation Result of Learning Implementation

Both classes used the same material in mathematics found in the student book despite having quite different learning models. While the control class learned conventionally, the experimental class used the TaRL approach to learning. The teacher moderately used the TaRL method, according to observations of his activities in the experimental classroom during sessions. The instructor was able to manage 15 out of 20 indicators with a 75% completion rate, see Table 1.

Table 1. Observation Results of Learning Implementation

Steps	Experiment Class				Control Class			
	Session I		*Session II*		*Session I*		*Session II*	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
Initial Activity	√	√	√	√	√	√	√	√
Core Activity	√	√	√	√	√	√	√	√
End Activity	√	√	√	√	√	√	√	√
Quantity	15	5	18	2	8	12	11	9
Persentase (%)	75%	25%	90%	10%	40%	60%	55%	45%

Learning activities in the second session of the experimental class were largely the same as those in the first session. The educator observed teacher activities during sessions using the TaRL approach in the experimental class. II. At the end of the activity, 18 out of 21 indicators had a percentage of 90%, indicating a 14% increase in educator activity—observation of educator activities in the control class in sessions. I, the educator, can carry out eight indicators out of 20 indicators with a percentage of 40%. In session II of the control class, the educator carried out 11 indicators out of 20 indicators with a percentage of 55%. The results obtained are different between the experimental class and the control class. The difference is due to a different learning treatment, which encourages experimental students to have more critical thinking skills than the control class.

3.2. Critical Thinking Skills

The following Table 2 shows the results of the learning pretest and posttest for the experimental class using the TaRL approach in learning and the control class using conventional learning.

Table 2. Critical Thinking Test Results

Name	Aspect/Indicator			
	1	*2*	*3*	*4*
Pretest Experiment	87	71	60	56
(%)	87%	71%	60%	56%
Posttest Experiment	92	89	82	61
(%)	92%	89%	82%	61%
Pretest Control	80	71	56	53
(%)	80%	71%	56%	53%
Posttest Control	90	83	70	62
(%)	90%	83%	70%	62%

The 20 students who got the pretest learning results of critical thinking skills in the experimental class showed that the average in aspect 1 got a good category with a percentage of 87%, aspect 2 got a category less with a percentage of 71%, aspect 3 got a category less with a percentage of 60% and aspect 4 got a category less with a percentage of 56%. Like previous research by Afandi *et al.*, applying the TaRL learning approach can increase activity and student understanding [18]. The results of the ability to think critically in the context of the experimental class have a fairly high value because teaching and learning activities use the TaRL approach in learning mathematics. Learners totaling 20 get learning outcomes. Critical thinking ability after the experimental class test shows that the average in Aspect 1 gets a very good category percentage of 92%, aspect 2 gets a good category percentage of 89%, aspect 3 gets a good category percentage of 82%, and aspect 4 gets a category less percentage of 61%. This is in accordance with Mustafa's research, which shows that the TaRL method can improve students' critical thinking skills and math skills [24]. Both the pretest and posttest of the experimental class showed an increase. This shows that the TaRL strategy can improve critical thinking skills in math stories [25]. The 20 students who got the pretest learning results of critical thinking skills of the control class showed that the average in aspect 1 got a good category percentage of 80%, aspect 2 got a sufficient category percentage of 71%, aspect 3 got a category less percentage of 56%, and aspect 4 got a category less percentage of 53%. Yohannes *et al*. said that students' critical thinking skills were affected by the problem-solving approach in solving math story problems; the results of the pretest and posttest data analysis showed an increase [6]. The 20 students who got the

posttest learning results of critical thinking skills in the control class showed that the average in aspect 1 got a good category percentage of 90%, aspect 2 got a good category percentage of 83%, aspect 3 got a category less percentage of 70% and aspect 4 got a category less percentage of 62%, see Fig. 1.

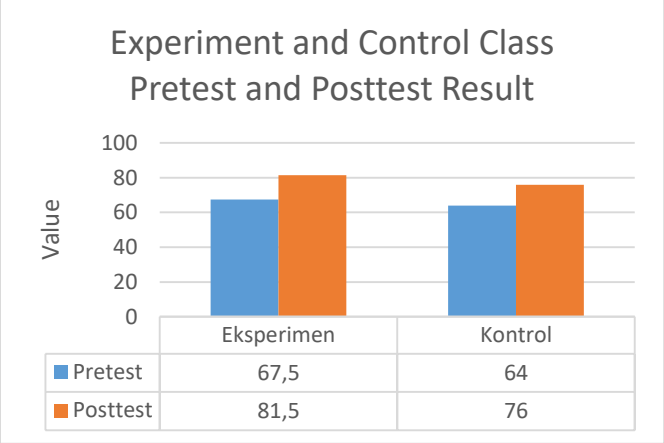

Fig. 1. Pretest and Posttest Results of Experimental and Control Classes

The experimental class's pretest and posttest calculation results increased by 67.5 to 81.5, while the control calculation results increased by 64 to 76. Thus, it can be said that learning with the TaRL approach increases student learning outcomes. The improvement that occurred during this learning process had an impact on students' critical thinking skills. Their capacity to think critically when solving math problems was assessed using the pretest findings. Data analysis showed that the control class pretest and posttest data were better than the average. This conclusion shows that the average increase in the experimental class is greater than the average of the control class. By using the TaRL approach, the average value of students' learning outcomes on the KPK and FPB material stories increased. It also shows that learners better understand the math concepts that have been taught.

3.3. The Effect of the TaRL Approach on Critical Thinking Skills

The pretest and posttest results of the control class obtained a t of 7.151 with a sig value (2-tailed) of 0.000. The significance value states are smaller than 0.05, so it can be concluded that Ho is rejected and Ha is accepted. Student learning activities show this, supporting previous research [26], which found that using learning models can improve critical thinking skills once again. However, all learning models cannot automatically improve critical thinking skills. The comparison test used an independent sample t-test using posttest data of experimental classes using the TaRL approach and control classes using a scientific approach with a conventional learning model. The results of data processing show that sig (2-tailed) is 0.001, then 0.001 < 0.05. So it can be concluded that Ho is rejected and Ha is accepted, using the TaRL approach is higher than using conventional learning, see Table 3.

Table 3. Independent Sample T-Test Results

Independent Samples Test										
		Levenes's Test For Equality of Variances		*t-test for Equality of Means*						
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*95% Confidence Interval of the Difference*	
									Lower	*Upper*
Results	Equal variances assumed	3.058	.883	1.857	38	.001	5.500	2.962	-.497	11.497
	Equal variances are not assumed.			1.857	32.479	.001	5.500	2.962	-.531	11.531

The data comparison shows a strong correlation between using TaRL techniques and developing critical thinking skills when dealing with math difficulties. It becomes the main tool to teach students to engage in critical thinking through the application of the TaRL approach in teaching and learning

activities. Students' abilities show how learning involves thinking activities and processes. Since not every student is gifted in the same way, teachers can use the TaRL approach to help students develop their critical thinking skills. The results of several previous studies and research show that learning activities using the TaRL approach can improve learners' critical thinking skills in solving mathematics problems, especially those related to the material of KPK and FPB. This is due to the fact that learners are required to perform activities while thinking to complete the task, which improves their critical thinking ability.

4. Conclusion

The results of the research and discussion show that applying the learning approach at the right level (TaRL) impacts students' critical thinking skills when solving mathematics problems in class IV at Muhammadiyah Elementary School Ngijon 1. The results of the posttest of critical thinking skills in the experimental class showed that aspect 1 understood the question by 92%, aspect 2 made a model by 89%, aspect 3 provided an explanation by 82%, and aspect 4 concluded by 61%. Other results can be seen from the results of hypothesis testing using independent sample t-test data pretest and posttest experimental class, which showed a sig value (2-tailed) of 0.001. The significance value states $\alpha < 0.05$; it can be concluded that Ho is rejected and Ha is accepted. In addition, it can also be seen from the average post-test results of the experimental class that applied the TaRL approach of 81.5 percent 82% with a good category, with the highest score of 100 and the lowest score of 55, while the average post-test of the control class that used conventional learning was 76 percentage 76% with a sufficient category with the highest score of 90 and the lowest score of 60. The TaRL method, as an alternative for learning, can be used to improve students' critical thinking skills. The results show that applying this method can significantly affect students' ability to solve math problems in grade IV elementary school.

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